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MEMRISTORS FOR SOCIETAL ACTION AND CHANGE

Within an information management domain, this conceptual paper provides and benefits from information on memristance/memristors and their possible applications into physical and social sciences in order to develop analogies among electrical, mechanical and social sciences to be used for an original and innovative model development for societal change and action. Possible implications such as utilization of social memristors for social movements, as well as development of artificial intelligence hardwares could be drawn from this work. This paper is a follow-up about the work on Circuits of Power in Quantum Organizations: Memristors for Post-Pandemic Consciousness in order to develop and suggest a new model of societal action benefiting from analogies among electrical sciences, mechanical sciences and social sciences. Accordingly this paper first gives background information on the related concepts of memristors and their possible applications into physical and social sciences. Benefiting from this background information, then, analogies among electrical, mechanical and social sciences will be used for a model development for societal change and action. A discussion for possible implications will also be provided, before the conclusion.

Key words: memristor, societal action, artificial intelligence, information management.

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Қоғамдық әрекеттер мен өзгерістерге арналған мемристорлар

Ақпаратты басқару саласында бұл концептуалды құжат электрлік, механикалық және әлеуметтік ғылымдар арасындағы ұқсастықтарды дамыту мақсатында мемрисенттер/мемристорлар және олардың физикалық және әлеуметтік ғылымдардағы ықтимал қолданбалары туралы ақпаратты ұсынады және одан пайда көреді. қоғамдық өзгерістер мен әрекет. Бұл жұмыстан әлеуметтік мемристорларды әлеуметтік қозғалыстар үшін пайдалану, сондай-ақ жасанды интеллект техникасын дамыту сияқты ықтимал салдарларды алуға болады. Бұл мақала электрлік ғылымдар, механикалық ғылымдар арасындағы аналогиялардан пайда алатын әлеуметтік әрекеттің жаңа моделін әзірлеу және ұсыну үшін кванттық ұйымдардағы қуат тізбектері: постпандемиядан кейінгі сананың естеліктері бойынша жұмыстың жалғасы болып табылады. Тиісінше, бұл жұмыс алдымен мемристорлардың байланысты концепциялары және олардың физикалық және әлеуметтік ғылымдардағы мүмкін қолданылуы туралы негізгі ақпарат береді. Осы бастапқы ақпаратты пайдалана отырып, электр, механикалық және әлеуметтік ғылымдар арасындағы ұқсастықтар қоғамдағы өзгерістер мен әрекетті дамыту үлгісі үшін пайдаланылады. Қорытындыға дейін ықтимал салдарларды талқылау ұсынылады.

Түйін сөздер: мемристор, әлеуметтік әрекет, жасанды интеллект, ақпаратты басқару.

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Мемристоры для общественных действий и изменений

В области управления информацией этот концептуальный документ предоставляет и извлекает выгоду из информации о мемристансе/мемристорах и их возможном применении в физических и социальных науках, чтобы разработать аналогии между электрическими, механическими и социальными науками, которые будут использоваться для разработки оригинальной и инновационной модели для социальные изменения и действия.

Из этой работы можно извлечь возможные последствия, такие как использование социальных мемристоров для социальных движений, а также разработка аппаратного

обеспечения искусственного интеллекта. Эта статья является продолжением работы «Схемы власти в квантовых организациях: мемристоры для постпандемического сознания» с целью разработки и предложения новой модели социального действия, основанной на аналогиях между электрическими (а значит, электронными и информационными) науками, механическими науки и социальные науки.

Соответственно, в этой статье сначала дается справочная информация о родственных концепциях мемристоров и их возможном применении в физических и социальных науках. Затем, используя эту справочную информацию, аналогии между электрическими, механическими и социальными науками будут использоваться для разработки модели социальных изменений и действий. Перед заключением также будет проведено обсуждение возможных последствий.

Ключевые слова: мемристор, социальное действие, искусственный интеллект, управление информацией.

Introduction

This paper is a follow-up about the work on Circuits of Power in Quantum Organizations: Memristors for Post-Pandemic Consciousness (Medeni, Soylu, Medeni, 2020) in order to develop and suggest a new model of societal action benefiting from analogies among electrical (thus electronic and informatic) sciences, mechanical sciences and social sciences.

Accordingly this paper first gives background information on the related concepts of memristors and their possible applications into physical and social sciences. Benefiting from this background information, then, analogies among electrical, mechanical and social sciences will be used for a model development for societal change and action. A discussion for possible implications will also be provided, before the conclusion.

Background Literature

Resistance (voltage + current), capacitance (voltage + charge) and inductance (magnetic flux + current) are the three essential circuit elements that "depend on relationships between pairs that control how electricity flows, how it gets stored and how it changes as it moves through a circuit". It is then suggested by Chua (1971) a fourth circuit element, which would operate as a resistance with memory, i.e. memristance (memory + resistance), governing the relationship between the 'missing' pair – charge and flux". Accordingly Memristor's resistance (memristance) would not be constant but dynamic, "determined by the history of the current that had flowed through the device". (Volk 2018) (Figure 1)

As resistive elements that retain their past information, memristors also display noteworthy quantum mechanics characteristics that could support their functions as organic or artificial memory instruments (Medeni, Soylu, Medeni, 2020, Penrose 1999, Hameroff, 2012, Hameroff & Penrose, 2014), even leading to suggestions such as quantum memristors (Pfeiffer et al. 2016, and Salmilehto et al. 2017), exhibiting entanglement, superposition and wave collapsing dynamics.

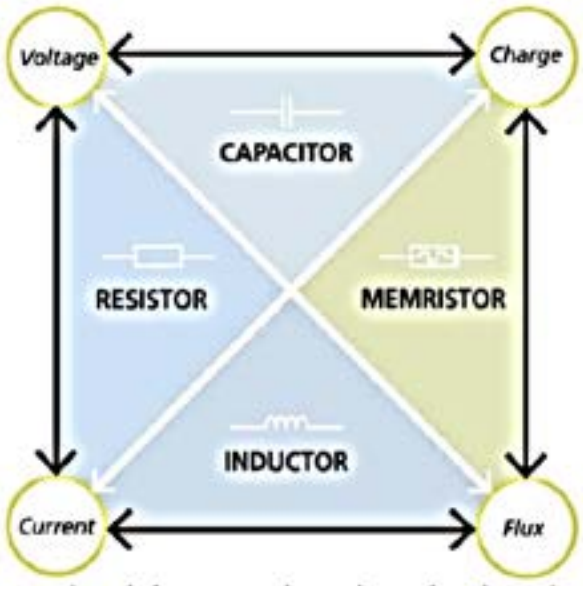

Figure 1 – Interlink between resistor/resistance, capacitor/capacitance, inductor/inductance and memristor/ memristance (Volk 2018)

Recently, for instance, memristors have begun to be used in hardware security applications, allowing development or redefinion of memristor-based physical (unclonable) functions. (Lvi, Liu, Gang 2021; diyot.net, n.d.) Furthermore, as suggested by Medeni, Soylu, Medeni (2020), resistance with memory would be a useful contribution to conceptual modelings that try to incorporate resistance and circuits of power into social and

managerial sciences such as those of Clegg (for example, Clegg 1989, or Simpson, Clegg, Freeder 2013, Smith et al. 2010). Furthermore, the quantum mechanics that could be linked with the functioning of memristors could also pave the way for a better comprehension and utilization of organizational memory and consciousness, suggesting to identify societal memristors (or microtubules) that could "accommodate multiple and relative perspectives, uncertainty, contextuality and multiple possibilities.", with potential implications for the pandemi and post-pandemi period:

"It seems the whole world is expecting to see which scenario will unfold, or, in terms of quantum mechanics, into which single state the pandemic wave will collapse, which, perhaps, will then give rise to our consciousness that will in return influence interactions at micro, meso and macro levels within the circuits of power. Within these circuits of power, not only resistance but also memristance will enable determination of the related interactions and their consequences, supporting both movement (physical action and accord) and memory (intellectual and organizational record)." (Medeni, Soylu, Medeni, p.140).

"Perhaps, one possible elaboration could be based on the view that while resistors could underline interactions as part of existing conditions or knowledge, memristors could underline the past-tofuture direction for changing conditions and new knowledge, complementing each other." (Medeni, Soylu, Medeni, p.141).

Interlinking Electrical, Mechanical and Social Sciences for a Model Development

Analogies are commonly used to interlink different scientific domains for different purposes. Among these, Newtonian mechanical analogies can be used to explain freedom of speech and social movements (Tunçdemir 2022a). Or, mechanical and electricial analogies can be used, for instance, to explain electrical phenomena in familiar terms in order to make the learning of this phenomena easier. Furthermore, certain mechanical issues could be more easily solved benefiting from electrical analogies. One of these available analogies, Impedance analogies, for instance, interlink mechanical Force with electrical Voltage, Velocity with Current, Momentum with Flux, and Displacement with Charge (Wikipedia, n.d.) (Figure 2).

Type		Mechanical translation variable	Mechanical rotation variable	Acoustical variable	Analogous electrical variable
Power conjugate pair	Effort variable	Force	Torque	Pressure	Voltage
	Flow variable	Velocity	Angular velocity	Volume flow rate	Current
Hamiltonian variables	Effort Hamiltonian	Momentum	Angular momentum	Pressure-momentum	Flux linkage
	Flow Hamiltonian	Displacement	Angle	Volume	Charge

Figure 2 – Impedance Analogy (Wikipedia, n.d.)

While there are different interpretations of these analogies, this impedance analogies that incorporate Hamiltonian variables (and thus Newtonian second law of motion) can be expanded to incorporate interpretations that will allow to make interlinks with memristance, organizational/collective consciousness and social movement related concepts that are introduced above.

To do so, benefiting from the illustrations provided in Figure 1 and Figure 2, the below modeling is developed. (Figure 3).

In order to develop this modeling, in addition to the analogies given above, Resistance is interlinked with Frictional coefficient (as self-explanatory), Capacitance (as an ability that implies an associated storage of electrical energy) with Spring mechanisms and Inductance with Mass and/or Inertia (as the tendency of an electrical conductor to oppose a change in the electric current flowing through it). (RF Wireless World, n.d.; Wikipedia, n.d.) Accordingly, the remaining part of the model that corresponds with Memristance could be interlinked with Acceleration of Mass that turns potential energy to Kinetic Energy. As a result, benefiting from the available capacitance, memristance could be interpreted as the main element that facilitates momentum and displacement that could result in motion and

movement, in accordance with Newton's 2nd Law of Motion to be applied for either physical or social sciences, which is in contrast to Newton's 1st Law of Inertia that corresponds with resistance and inductance. One implication of such interpretation is that a (collective) resistance that is able to remember and demand, as implied by Tunçdemir (2022a), Smith et al (2010), Clegg (1989), and Chua (1971) may be needed to initiate societal action and movement, to be followed next.

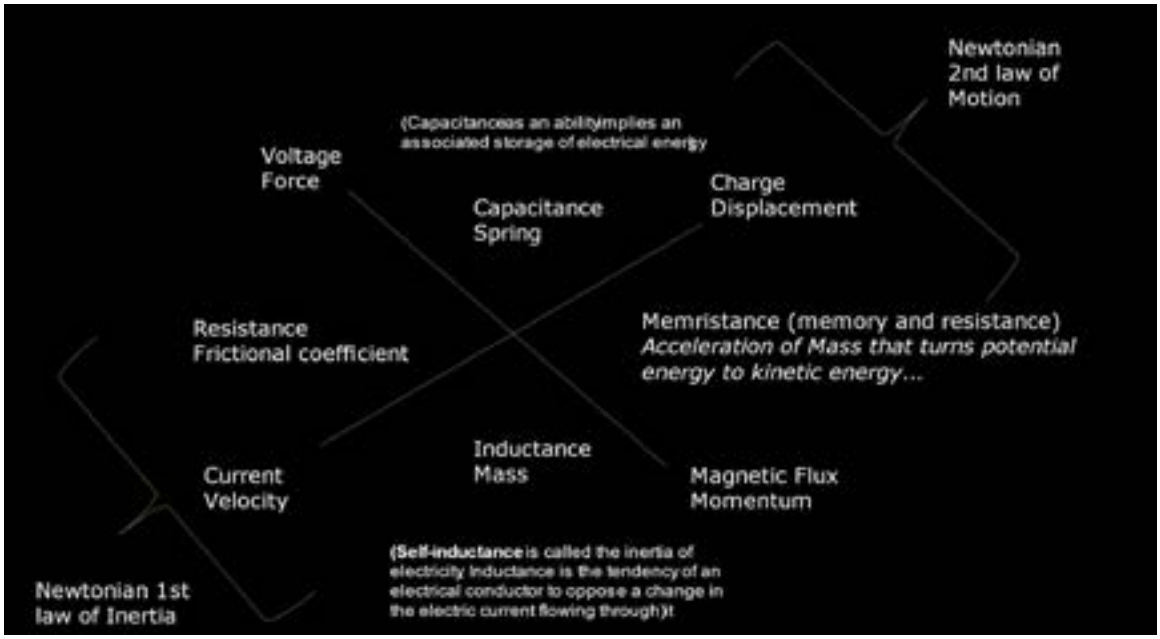

Figure 3 – Analogical Modeling of Memristance for Social Movement and Change

Discussion and Implications

Tunçdemir (2022a) suggests that Newton had been an important source of inspiration for Voltaire who then significantly contributed to constructing the foundations of French Renaissance and reformation that reshaped and transformed the whole world in the following periods. Accordingly, it is impossible for societies to get freedom, or authorities in charge to accept limitation of their power for the benefit of citizens, considering the natural inertia. Only if a power such as demands from the people is applied onto the powers-that-be, a movement towards (further) freedom can be enabled. Accordingly, the first law of freedom is active demand: only societies who demand it can obtain freedom; and this demand also needs to be maintained in order to sustain the freedom.

These remarks from Tunçdemir (ibid.) resonate well with Smith et al. (2010) and Chua (1971) "power is never one-way traffic: an A rarely gets a B to accede to direction without some resistance" (Smith et al, 2010 p. 466), while the resistence should be expected from both sides, for instance from both employees and management, or from both governors and citizens. As one type of resistance, "under rare conditions called 'organizational out-flanking,' resistance to power may consolidate itself as a new power and thus constitute a new fixity in the representation of power, with a new force field altogether." (Clegg 1989, p.207 in Smith et al. 2010, p. 467).

Capable of creating an altogether new force field, Chua's (1971) memorising resistors could then be integrated with Clegg's (1989) 'circuits of power' framework that illustrates "power as flowing through interacting circuits", as available or potential natural and/or social means to initiate and sustain change towards movement against inertia in these natural or social circuits of power. Accordingly, memristors' function could be interpreted as "obligatory passage points", such as a kind of refractive membrane operating in information systems as another analogy and metaphor to benefit from (Medeni and Umemoto, 2008).

While the circuits of power framework distinguish different interactions, dynamics and other aspects at micro, meso and macro levels

(as discussed in Medeni, Soylu, Medeni 2020); memristors such as microtubules seem to be a better fit for playing a critical role specifically at micro-level. Accordingly, another implication could benefit from the focus on memristor's ability that allow us work on hardware, in contrast to software. (Lvi, Liu, Gang 2021; diyot.net, n.d.).

As Lvi, Liu, Gang (2021) discusses, memristors have already become a crucial discovery for hardware security, with applications such as physical unclonable functions and chaotic circuits, replacing transistors with a single memristor or memristor crossbars. Since, resistance can vary with the current in accordance with a common memristance characteristic, the output of the voltage can also change, enabling a key applicable in hardware security.

"When the voltage changes continuously, the formation of the two states in resistance conversion is referred to as switching characteristics. The values of both the high-resistance state (HRS) and low-resistance state (LRS) correspond to "0" and "1," respectively" (Lvi, Liu, Gang, 2021, Figure 3a, and its explanation, https://onlinelibrary.wiley.com/doi/full/10.1002/aisy.202000127)

Furthermore, (while contradicting to each other) both randomness and reliability characteristics created by memristors could also enhance hardware security features. Additional characteristics such as high integration would also enable applications such as microchip miniaturization. Memristors ability to remember and keep its previous state even in the loss of power could also be applied into develop brain-like nerve morphology calculation, and nonvolatile memory and logic operation. (ibid.) Accompanied with quantum mechanics characteristics (or other developments such as smart transistors (Fizikhaber, 2021)), these applications could suggest other significant progress potentials on hardwares.

Accordingly, in addition to these characteristics and application opportunities of memristors in the field of hardware security, it could also be possible to identify new opportunities to develop artifical intelligence (AI) functions at hardware-level, benefiting from the HRS and LRS resistance states as 0s and 1s, or capabilities such as nonvolatile memory and logic operations (or simple rule-based algorithms) that could be integrated and embedded at micro level into suitable hardwares. This expansion into new hardware AI domain could then lead us to even distinguish hardware and software AI.

This distinction between hardware and software AI could address critiques that underline current AI's being neither artificial nor intelligent, as it is "made from natural resources and it is people who are performing the tasks to make the systems appear autonomous." (Corbyn, 2021, and Crawford 2021), making real value of AI limited mostly to efficient operationalization of autonomous tasks or tasks that are used to be associated (and have already been well addressed) with other scientific fields such as business intelligence. Meanwhile, software developments for AI could be open to critical argumentation, hardware developments for AI seem to be gaining attention. (for instance, frontiersin.org, n.d.) Accordingly, memristors could be essential to develop new artificial and intelligent hardwares that are to be distinguished from those to be associated with softwares.

These developments could then, for instance, shed light on being able to distinguish real, more sophisticated, in-depth AI software applications from simpler, superficial but functional forms of AI that could be embedded into hardware. For our simple and routine tasks that could be automated, micro-level hardware AI solutions would be recognized to be a better fit. And perhaps, this distinction and recognition could re-ignite a tradition and legacy that follows Al-Jazari's automata (Jeremy Norman's HistoryofInformation.com n.d.) or Mechanical Turk (Josic, n.d.). In fact, devices with autonomous abilities have already been available for quite some time, however, new developments in memristors could provide leaner, more effective solutions compared to older periods and versions respectively.

As another follow-up on previous related work, Medeni (2018) suggests, there are two different alternatives with respect to a socio-economic environment where human and robot resources could be and work together (p.261):

- *Robot acts like (and understood as) Robot,*
- *Robot acts like (and understood as) Human*

Robots acting and being understood as robots (RABUS) could corresponds well with hardware AI, while robots acting and being understood as humans (RABUH) could do so with software AI, both of which would contribute to making human life better. Such distinction could address some of the ethical issues related with AI such as to what extend robot resources be recognized as sentient beings with ethical responsibilities and rights, similar to those of human resources: While RABUH would be a better option to whom to designate such rights and responsibilities, RABUS could be discriminated not to be done so, if one has to choose from these two alternative options. By all means, nevertheless, the more important ethical issue that has emerged recently and still remains to be addressed is human's

acting and being understood as robot, as suggested by Medeni (ibid.).

In the mean time, the legacy of Mechanical Turk finds a critical interpretation at Amazon Mechanical Turk (https://www.mturk.com/, n.d.), as, among others, a noteworthy example of crowdsourcing platforms, as representation of (human) collective intelligence. Meanwhile, (both original and) present Mechanical Turk is being criticed for unfair labor treatments (Medeni, 2021, Schwartz, 2019a, Schwartz, 2019b, Milland, 2019, Vincent, 2014), confirming the problematic issue that both artificial and organic life-forms and work resources be considered as not themselves but each other, as well.

Still, whether human-based or AI-based, collective intelligence could facilitate a large-scale interaction for learning and change. "Citizen Science" projects could even now be considered as a hybrid example of this facilitation that combines artificial and human(-e) elements. Accordingly, artificial and social memristors' micro-level roles could be reinterpreted as to be carried to mezo and macro level roles and impacts in a collective sense, reinforcing their capacity to initiate and sustain societal action and social movement. (Wikipedia, 2021, National Geographic, n.d.)

In addition, these developments could help us reinterpret the needs hierarchy in the digital age. While Maslow's original work allow us to establish a logical relation between different needs of individual entities, further interpretations could also be made, considering different understandings of human nature and demands of digital times. (Medeni et. al., 2020). Accordingly, while some of these interpretations of needs hierarchy suggest that "addressing moral needs of human are more significant than addressing material needs" (p.66), some others recommend different technological tools to address these various needs of individuals. Besides, a similar relation can also be developed for organizational entities (Medeni et. al., 2020). With respect to this, organizations could also, for instance, have basic survival needs that could be addressed by a consistent cash flow. One then could hope to expect an evolution for the needs of organizational entities in a way similar to those of individual entities, as moral and social concerns become more important.

Then, interactions among these different needs of individual and organizational entities could also be suggested, especially addressing the demands of the digital age. Even, relations of and interactions with needs of artificially constructed entities could also be considered, benefiting from a hybridization of those for individiual and organizational entities, which would also be in accordance with the perspective that suggests an AI-based collective intelligence in this paper. Accordingly, artificial entities could be considered as a hybrid of individual entities and organizational entities. The needs of these artificial entities could then be a hybridization of those of individual and organizational entities existing in a society. Whether addressing higher level moral needs of artificial entities would be more significant than addressing basic level survival and materialistic needs or not would then also depend on the design, experience and evolution of these artificial entities in time. Nevertheless, by all means it could be good to distinguish the individual and organizational entities for the sake of both natural and artificial ones. (Figure 4)

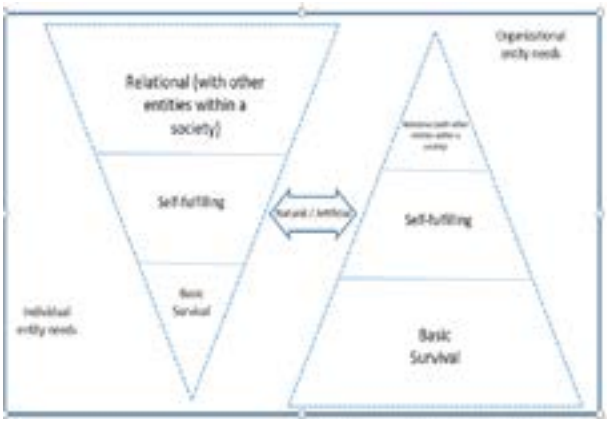

Figure 4 – Hierarchy of and Relations among Needs for Different Natural or Artificial Entities in the Digital Age (Adapted from Medeni et. al., 2020)

Conclusion

As among the most significant needs to be addressed (as suggested above), or birth rights to be possessed (as discussed elsewhere, for instance, Tunçdemir, 2022b), equality and freedom are surely within the most important aspects of human nature living in a society. In the mean time "general will" of this collective entity could be interpreted differently and cause great problems for the society and humanity. With the introduction of artificial entities existing as individual or collective/social entities, the situation surely becomes more and more complex, with questions more left-to-be-addressed than answered.

Still, this paper has suggested a model development for societal action, benefiting from analogies among electrical, mechanical and social

sciences with a particular focus on the introduction and interpretations of memristors and memristance related concepts and notions. Accordingly memristors could be useful as natural and/or social means to initiate and sustain change towards movement against inertia as part of natural or social circuits of power. Another implication for future direction could also be the focus on memristor's ability to develop hardware-based artificial intelligence. Surely, these conceptual suggestions need to be further studied and throughoutly discussed in order to develop a sound base for useful academic and practical implications, but are still hoped to provide an initial interesting and prospective vision for future.

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